Applications Manual for TUXS

Rev. 7.0E   2-Sep-19

Contents

1 Pin Assignment

Fig.1.1
Pin configuration
(bottom view)

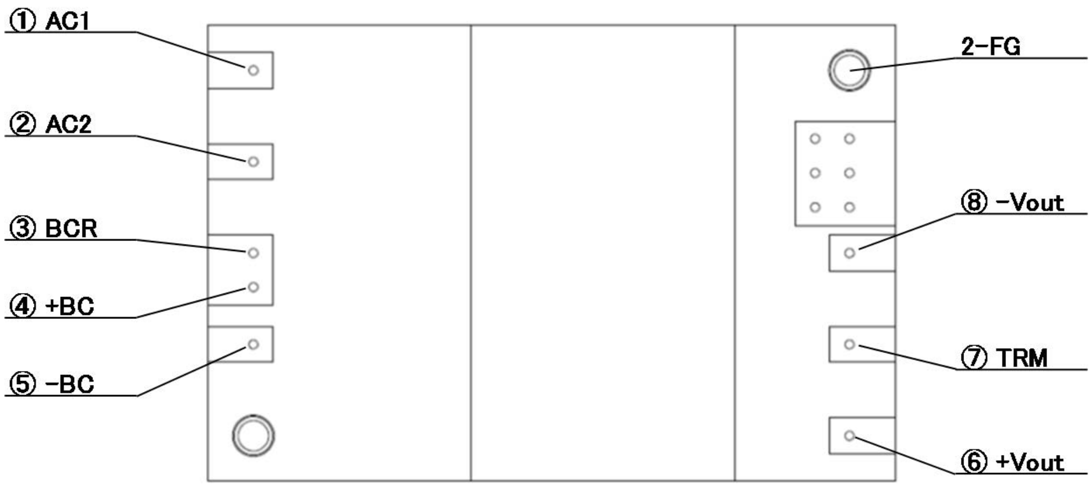


Table 1.1
Pin configuration
and function

No.	Pin Connection	Function
①	AC1	AC input
②	AC2	
③	BCR	+BC output
④	+BC	+BC output
⑤	-BC	-BC output
⑥	+VOUT	+DC output
⑦	TRM	Adjustment of output voltage
⑧	-VOUT	-DC output

2. Connection for Standard Use

2.1 Connection for standard use

■ To use the TUXS series, external parts should be connected as shown in Fig. 2.1 or Fig2.2.
■ The TUXS series should be conduction-cooled. Use a heatsink or fan to dissipate heat.

Fig. 2.1
Connection for
standard use #1

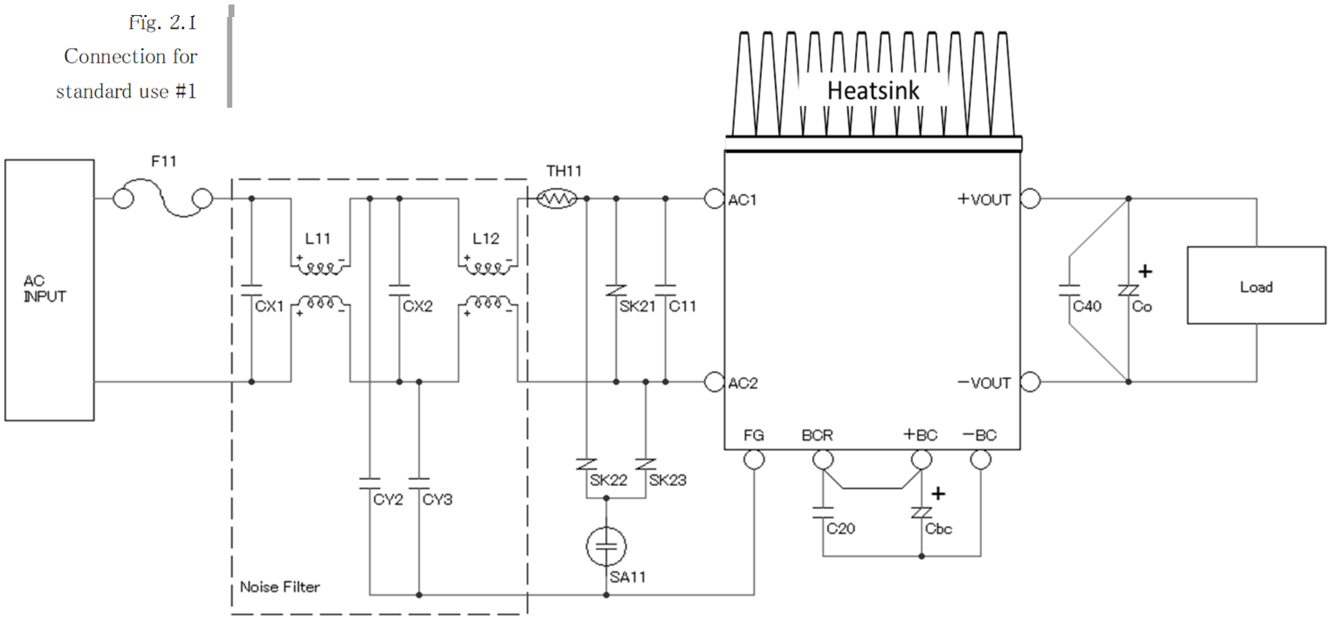
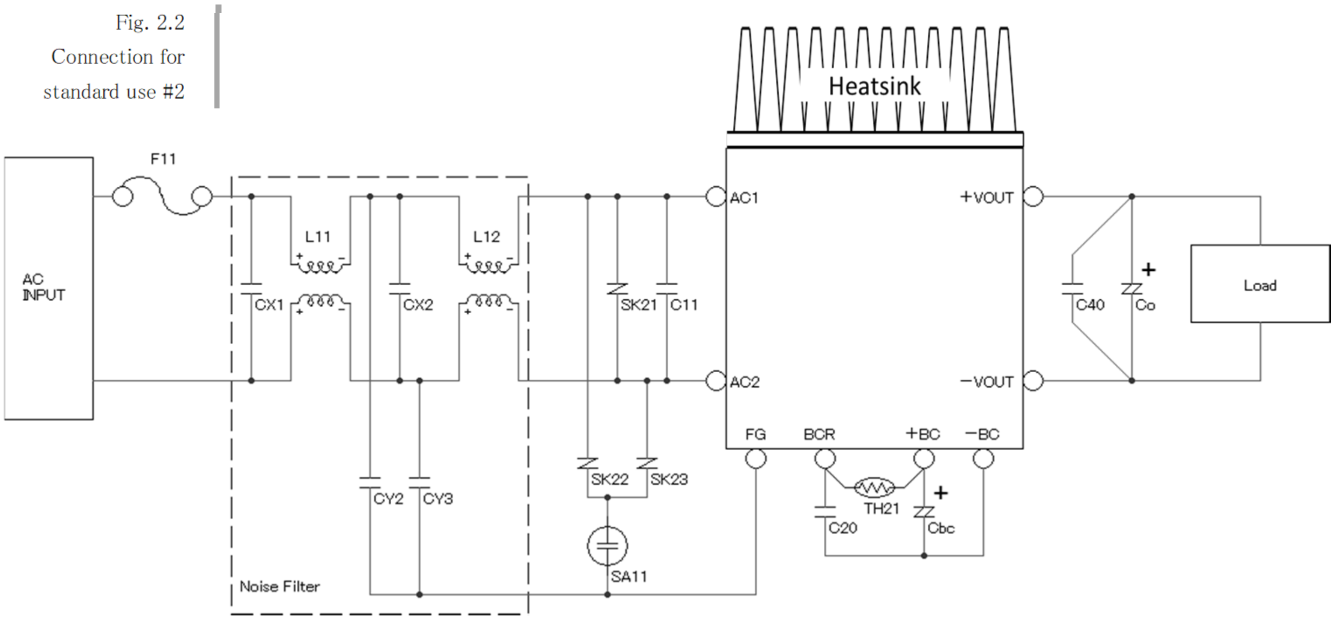


Fig. 2.2
Connection for
standard use #2



・Parts name are shown in Table 2.1 and Table 2.2 as reference.
・External parts should be changed according to the ambient temperature, and input and output conditions.
For details, refer to the selection method of individual parts.

Table 2.1
Parts name
(TUXS150)

No	Part	Item		Rating	Part name
1	F11	Input fuse		250V/5A	BL50 （Daito Communication Apparatus ）
2	C11	Input capacitor		AC310V/1uF	LE105-MX （OKAYA ELECTRIC INDUSTRIES ）
3	L11	Noise filter	Line Filter	10mH/4A	SCR-040-0R8A100JH （TOKIN ）
4	L12			10mH/4A	SCR-040-0R8A100JH （TOKIN ）
5	CX1		X capacitor	AC310V/0.68uF	LE684-MX （OKAYA ELECTRIC INDUSTRIES ）
6	CX2			AC310V/0.68uF	LE684-MX （OKAYA ELECTRIC INDUSTRIES ）
7	CY2		Y capacitor	AC250V/2200pF	CD45-E2GA222M （TDK）
8	CY3			AC250V/2200pF	CD45-E2GA222M （TDK）
9	Co	Output capacitor		DC80V/100uF	PCR1J101MCL1GS （Nichicon） ×2
10	C40	Bypass capacitor		DC100V/2.2uF	C3216X7S2A225K160 （TDK）
11	Cbc	Smoothing capacitor for boost voltage		DC420V/150uF	EKXJ421ELL151MM50S （Nippon Chemi-Con）
12	C20	Capacitor for boost voltage		DC450V/0.68uF	ECW-F2W684JA （Panasonic Electronic Components ）
13	TH11	Inrush current limiting resistor		12Ω	12D2-15LCS （SEMITEC）
	TH21	Inrush current limiting resistor		12Ω	12D2-11LCS （SEMITEC）
14	SK21	Varistor		470V	TND14V-471 （Nippon Chemi-Con ）
15	SK22,SK23	Varistor		620V	TND14V-621 （Nippon Chemi-Con ）
16	SA11	Surge absorber		3kV	DSA-302MA （Mitsubishi Materials）

Table 2.2
Parts name
(TUXS200)

No	Part	Item		Rating	Part name
1	F11	Input fuse		250V/6.3A	BL63 （Daito Communication Apparatus ）
2	C11	Input capacitor		AC310V/1uF	LE105-MX （OKAYA ELECTRIC INDUSTRIES ）
3	L11	Noise filter	Line Filter	7.5mH/6A	SCR22-060-1R0A075J （TOKIN ）
4	L12			7.5mH/6A	SCR22-060-1R0A075J （TOKIN ）
5	CX1		X capacitor	AC310V/1uF	LE105-MX （OKAYA ELECTRIC INDUSTRIES ）
6	CX2			AC310V/1uF	LE105-MX （OKAYA ELECTRIC INDUSTRIES ）
7	CY2		Y capacitor	AC250V/3300pF	CD45-E2GA332M （TDK）
8	CY3			AC250V/3300pF	CD45-E2GA332M （TDK）
9	Co	Output capacitor	F50	DC80V/100uF	PCR1J101MCL1GS （Nichicon） ×2
			F42	DC80V/100uF	PCR1J101MCL1GS （Nichicon） ×3
			F32	DC50V/180uF	PCR1H181MCL1GS （Nichicon） ×3
			F28	DC50V/180uF	PCR1H181MCL1GS （Nichicon） ×3
			F24	DC35V/270uF	PCR1V271MCL1GS （Nichicon） ×2
10	C40	Bypass capacitor		DC100V/2.2uF	C3216X7S2A225K160 （TDK）
11	Cbc	Smoothing capacitor for boost voltage		DC420V/150uF	EKXJ421ELL151MM50S （Nippon Chemi-Con）
12	C20	Capacitor for boost voltage		DC450V/1uF	ECW-F2W105JA （Panasonic Electronic Components ）
13	TH11	Inrush current limiting resistor		12Ω	12D2-15LCS （SEMITEC）
	TH21	Inrush current limiting resistor		12Ω	12D2-11LCS （SEMITEC）
14	SK21	Varistor		470V	TND14V-471 （Nippon Chemi-Con ）
15	SK22,SK23	Varistor		620V	TND14V-621 （Nippon Chemi-Con ）
16	SA11	Surge absorber		3kV	DSA-302MA （Mitsubishi Materials）

2.2 Input fuse: F11

■ No protective fuse is preinstalled on the input side. To protect the unit, install a slow-blow type fuse shown in Table 2.2 in the input circuit.

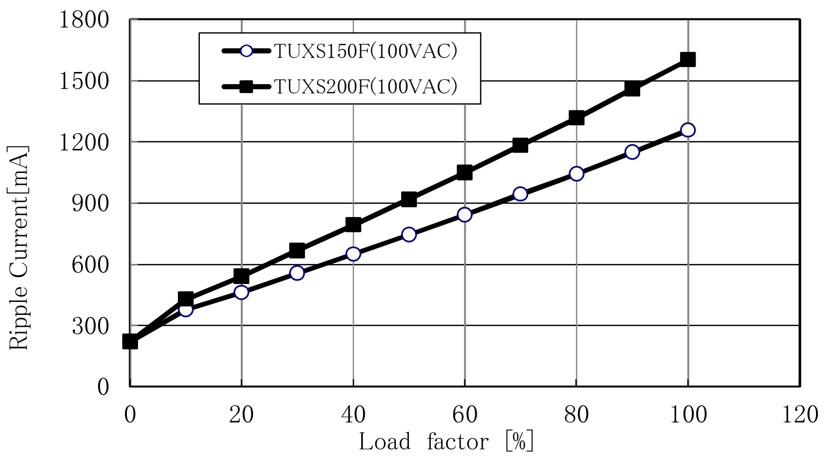
Table 2.2
Recommended fuse

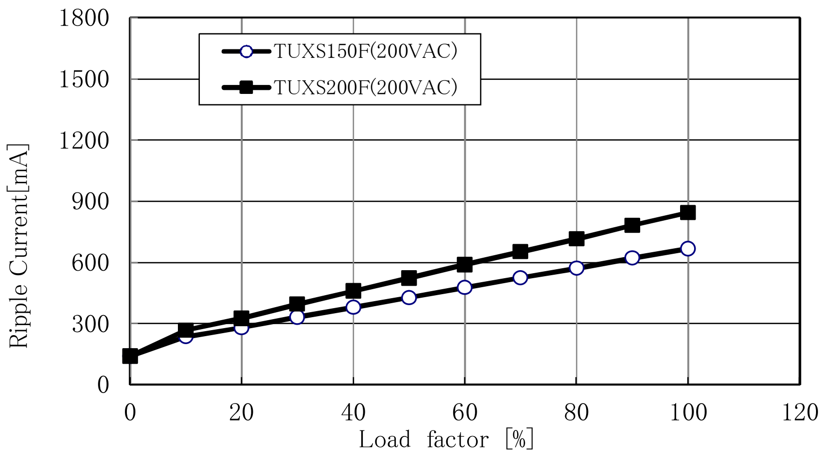
Model	Rated current
TUXS150	5.0A
TUXS200	6.3A

2.3 Input capacitor: C11

■ Connect a film capacitor of 1 uF or higher as input capacitor C11.
■ Use a capacitor with a rated voltage of AC250V which complies with the safety standards.
■ If C11 is not connected, the power supply or external components may be damaged.
■ Ripple current values flowing into C11 as listed in Table 2.1 and Table 2.2 are shown in Fig. 2.3.
■ The frequency of the ripple current is 80 kHz to 600 kHz.
■ When selecting a capacitor, check the maximum allowable ripple current.
■ The ripple current changes with PCB patterns, external parts, ambient temperature, etc. Check the actual ripple current value flowing through C11.

Fig. 2.3
Ripple current values
C11





2.4 Noise filters: CY, CX, L11,L12

- The TUXS series have no internal noise filter.
  Connect external noise filters and capacitors (CY) to reduce conduction noise and stabilize the operation of the power supply.
- Noise filters should be properly designed when the unit must conform to the EMI/EMS standards or when surge voltage may be applied to the unit.
- When the total capacitance of CYs exceeds 8,800 pF,the input-output withstanding voltage may be dropped. In this case, either reduce the capacitance of Y capacitors or install a grounding capacitor between output and FG.
- Use capacitors with a rated voltage of AC250V which comply with the safety standards as CY.
- Use capacitors with a rated voltage of AC250V which comply with the safety standards as CX.

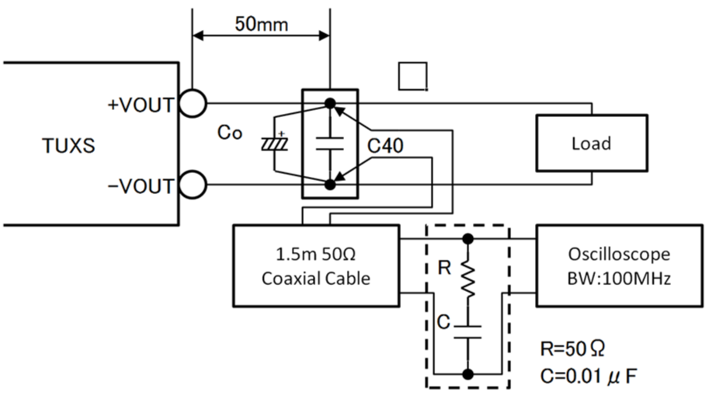
2.5 Output capacitors: Co, C40

- Install an external capacitor, Co, between +VOUT and -VOUT pins for stable operation of the power supply. Recommended capacitance of Co is shown in Table 2.3.
- Select the high frequency type capacitor. Output ripple and startup waveform may be influenced by ESR-ESL of the capacitor and the wiring impedance.
- When used at ambient temperatures below 0 °C, the output ripple voltage increases due to the characteristics of equivalent series resistance (ESR). In this case, use the capacitors, Co connnected in parallel to reduce the ESR.
- When using ceramic capacitors, in consideration of the capacitance is decreased by the bias characteristics of the components, and the use of the recommended or ceramic capacitor.
- Specifications, output ripple and ripple noise as evaluation data values are measured according to Fig. 2.4.

Table 2.3 Recommended capacitance Co

Model	Recommended Capacitance [uF]	Maximum Capacitance [uF]
TUXS150F50	220	2200
TUXS200F50	220	2200
TUXS200F42	330	3300
TUXS200F32	470	4700
TUXS200F28	560	5600
TUXS200F24	560	5600

Fig. 2.4 Measuring environment



2.6 Smoothing capacitor for boost voltage: Cbc

■ To smooth boost voltage, connect Cbc across +BC and −BC.
Recommended capacitance of Cbc is shown in Table 2.4.

■ Install a capacitor Cbc whose rated voltage is DC420 V or higher within the allowable capacitance.

■ When operated below 0°C, operation may become unstable as boost ripple voltage increases due to ESR characteristics. Choose a capacitor which has higher capacitance than recommended.

■ If the ripple voltage of the boost voltage increases, the ripple current rating of the smoothing capacitor may be exceeded. Check the maximum allowable ripple current of the capacitor.

■ The ripple current changes with PCB patterns, external parts, ambient temperature, etc.

■ Wire between BCR and +BC as short as possible in width.

Table 2.4 Recommended capacitance Cbc

Model	Recommended Capacitance [uF]	Allowable capacitance range [uF]
TUXS150	150	100 ～ 500
TUXS200		150 ～ 500

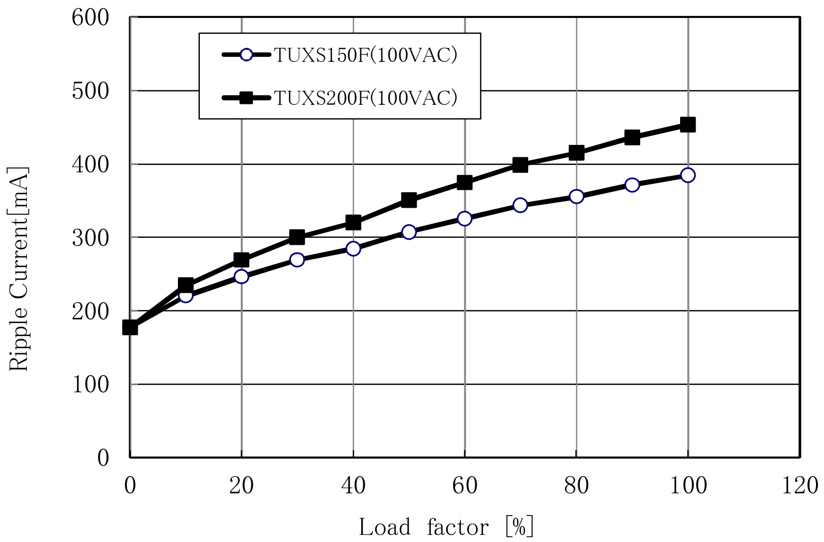
2.7 Capacitor for boost voltage :C20

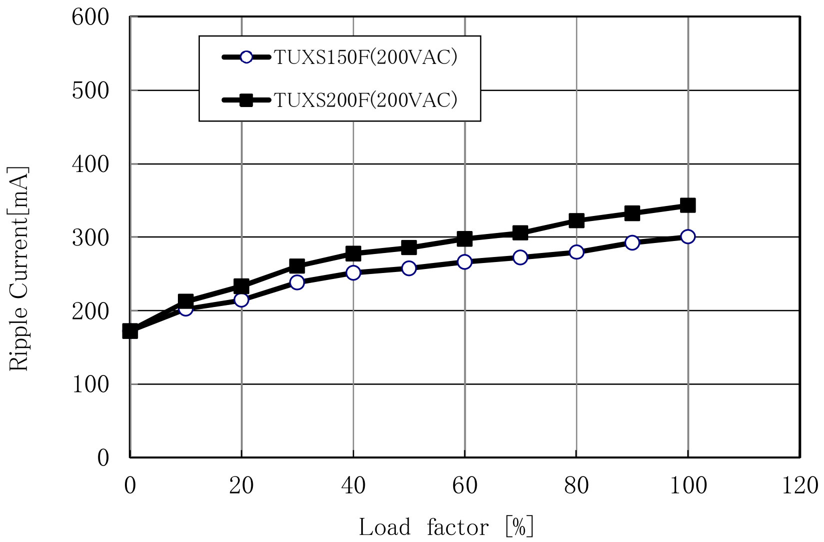
■ Install a film capacitor with a rating of Table 2.5 or higher as C20.
■ If C20 is not connected, the power supply or external components may be damaged.
■ Ripple current values flowing into C20 as listed in Table 2.1 and Table2.2 are shown in Fig. 2.5.
■ The frequency of the ripple current is 80 kHz to 600 kHz.
■ The ripple current flows into this capacitor. Check the maximum allowable ripple current of the capacitor when selecting.
■ The ripple current changes with PCB patterns, external parts, ambient temperature, etc. Check the actual ripple current value flowing through C20.

Table 2.5
Recommended
fuse

Model	Recommended capacitance [uF]
TUXS150	0.47
TUXS200	1

Fig. 2.5
Ripple current
values
C20





2.8 Inrush current limiting thermistor: TH11 / TH21

■The TUXS series have no internal inrush current limiting circuit.

■Inrush current may possibly damage internal components. Provide a power thermistor or inrush current limiting circuit in the input line to keep inrush current below 60A. The characteristics of power thermistor as shown in Fig. 2.6.

■When using a power thermistor and turning it ON/OFF repeatedly within a short period of time, keep appropriate intervals to allow the power supply to cool down sufficiently before turning on. Such intervals are also required when an inrush current limiting circuit is used.

■Inrush current values with external parts as listed in Table 2.1 are shown in Fig. 2.7.

■The inrush current changes by PCB pattern, parts characteristic etc. Check the actual inrush current value flowing through the AC line.

Fig. 2.6 Characteristics of power thermistor TH11

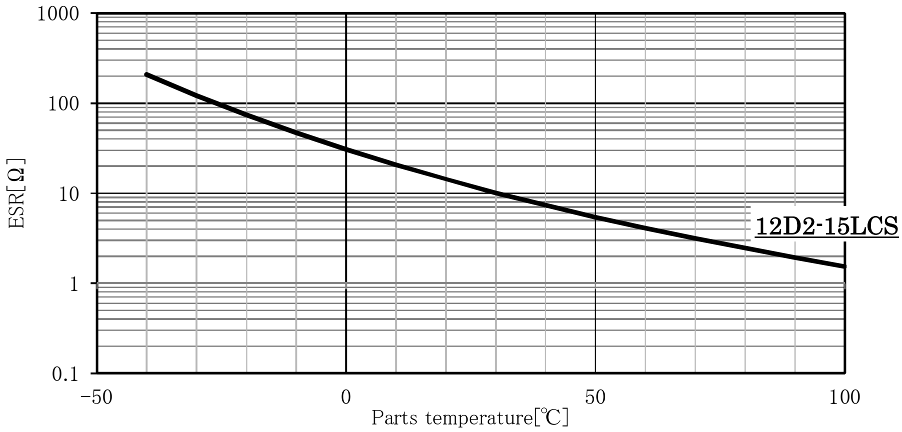
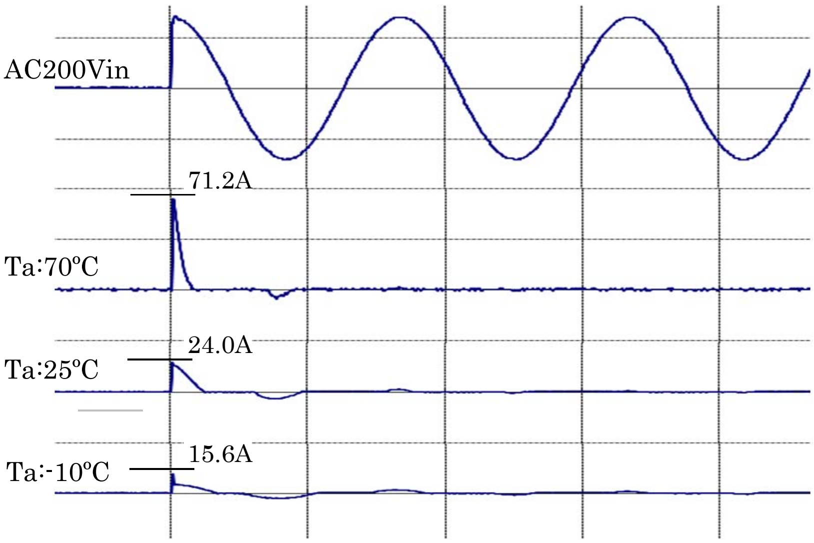


Fig. 2.7 Inrush current values



■At low temperatures, the output of power supply may be unstable due to high ESR values of the power thermistor and Cbc. Check with the actual device before use.
※Refer to section 4 for operation under low temperature conditions.

■ The inrush current can be suppressed by using a thermistor with a higher resistance for TH11 of basic connection 1.
※Please follow the rating according to the usage environment of the thermistor and make selection.

■ Basic connection 2, it is possible to operate with higher efficiency than basic connection 1. Figures 2.8 and 2.9 show efficiency comparisons.

Fig. 2.8
Efficiency comparisons
TUXS200F50
100VAC

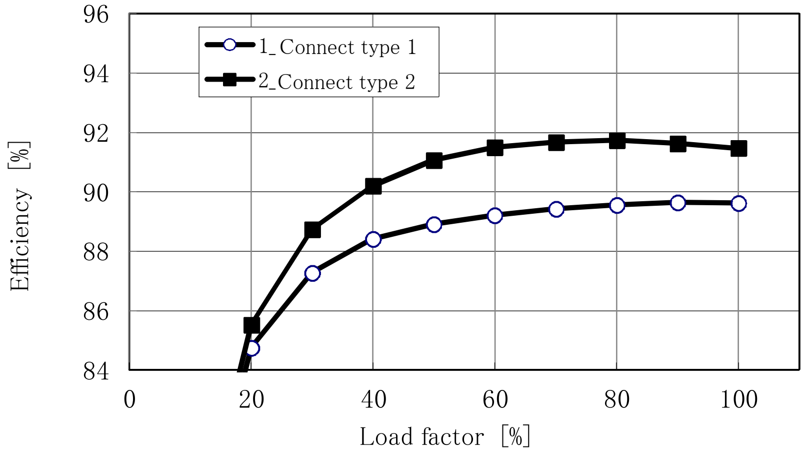
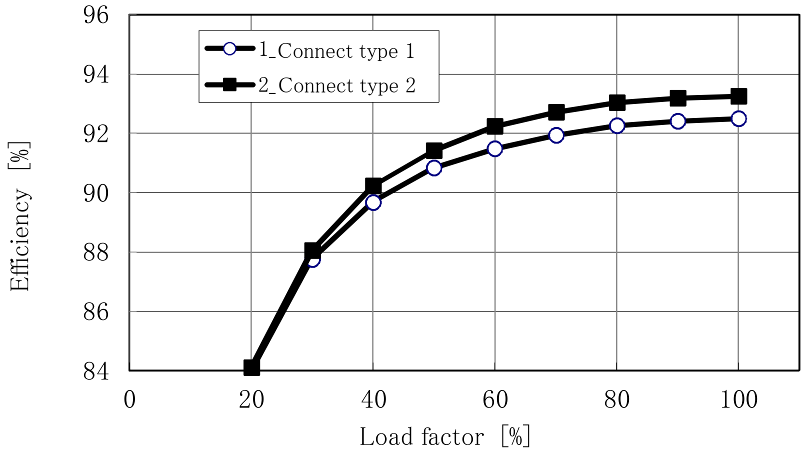


Fig. 2.9
Efficiency comparisons
TUXS200F50
200VAC



■ When using with basic connection 2, please refrain from using a thermistor other than recommended.
Unexpected damage or unstable operation may result.

3. Derating

3.1 Output current derating

- The TUXS series should be conduction-cooled.
- Fig. 3.1 and Fig. 3.2 shows the derating curve in relation with the temperature of the aluminum base plate.
  Note that operation within the shaded area will cause a significant level of ripple and ripple noise.
- Measure the temperature of the aluminum base plate at the center.
- Attention should be paid to thermal fatigue life due to temperature fluctuations by self-heating. Make the range of temperature fluctuations as narrow as possible if temperature often fluctuates.

Fig. 3.1
Output current derating
(TUXS150)

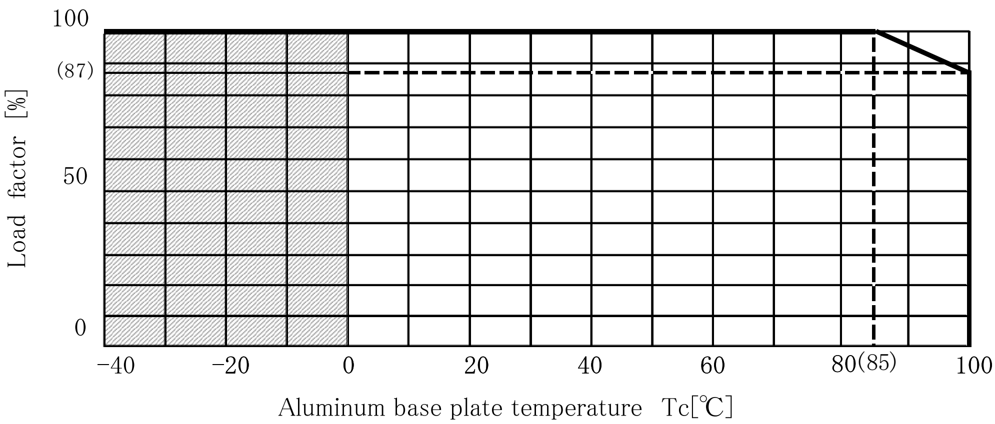
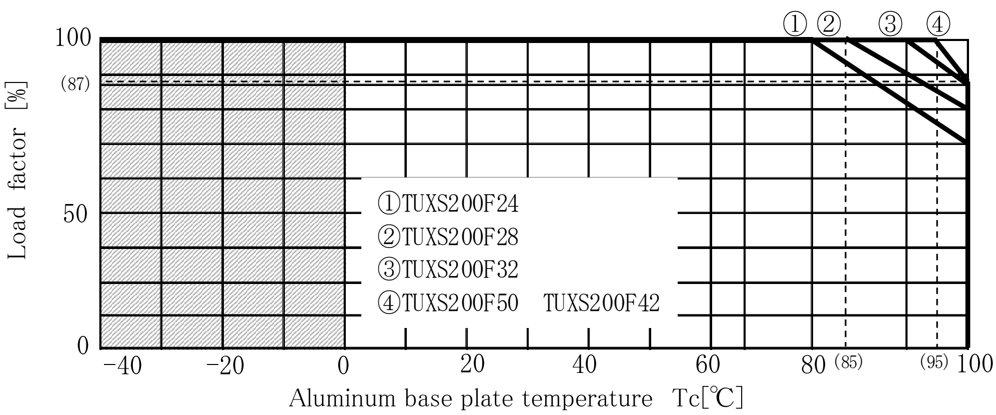
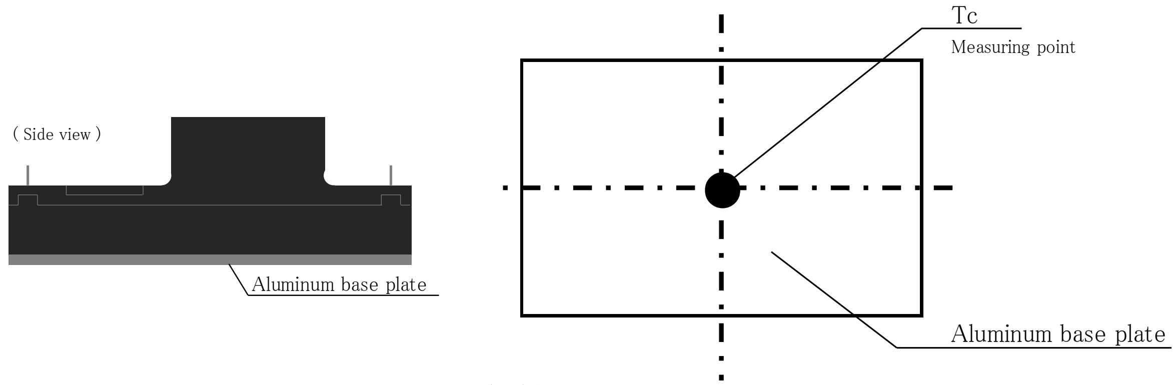


Fig. 3.2
Output current derating
(TUXS200)





4. Operation Under Low Temperature Conditions

4.1 Outline of low temperature operation (Connect type 1)

■ At low temperatures, output may become unstable immediately after startup or at dynamic load changes due to high ESR values of the thermistor and Cbc.
Check with the actual device before use.

■ Operation becomes stable as the temperature of the thermistor rises.

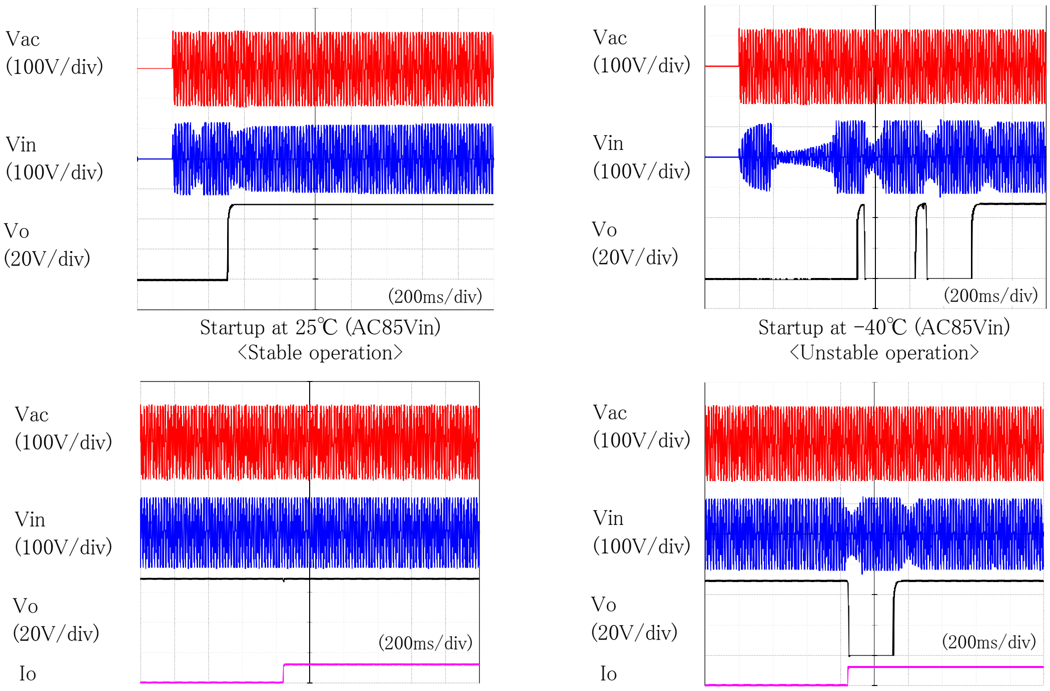
■ To prevent such unstable operation, choose a low ESR capacitor as Cbc, that has sufficient capacitance within the allowable range and excellent temperature characteristics.

<Notes for operation at ambient temperatures between -10°C and -40°C>

* Avoid the gradual increase of input voltage and forced air cooling.
* Output voltage may remain unstable at low load current. In this case, use the minimum load current.
* One minute after startup, the characteristics of TH11 and Cbc become stable, which then stabilizes output.
* If there is a minimum load , because the thermistor temperature rises , there is a case where unstable operation is eliminated .

■ Fig. 4.1 shows stable operation at 25°C and unstable operation at -40°C after startup and at dynamic load changes.

Fig.4.1
Difference of operation with temperature

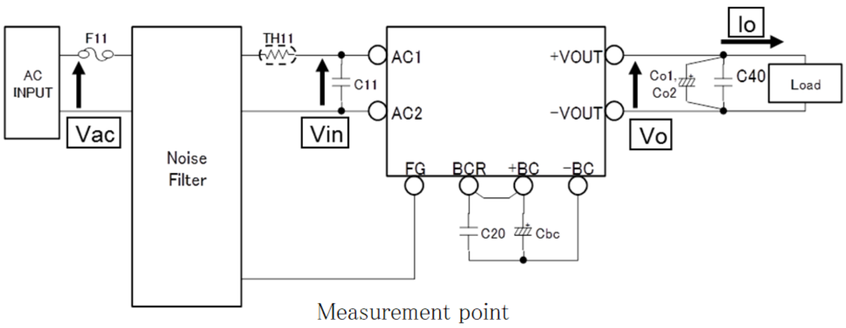


Startup at 25℃ (AC85Vin)
<Stable operation>

Startup at -40℃ (AC85Vin)
<Unstable operation>

Load 0% to 100% at 25℃ (AC85Vin)
<Stable operation>

Load 0% to 100% at -40℃ (AC85Vin)
<Unstable operation>



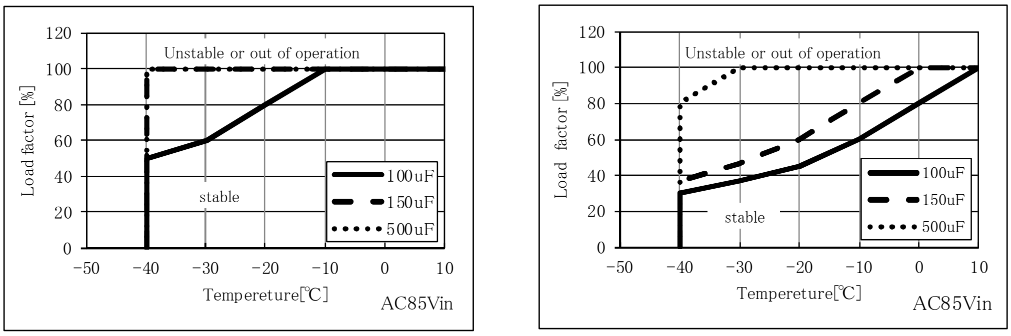
Measurement point

4.2 Improvement of unstable operation

■Unstable operation can be improved by increasing the capacitance of Cbc.
At low temperatures, increase the capacitance of Cbc within the range of recommended values.

■Fig. 4.2 shows the boundary line examples of stable and unstable operation.

Fig. 4.2
Boundary line of stable and unstable operation



Startup (AC85Vin)

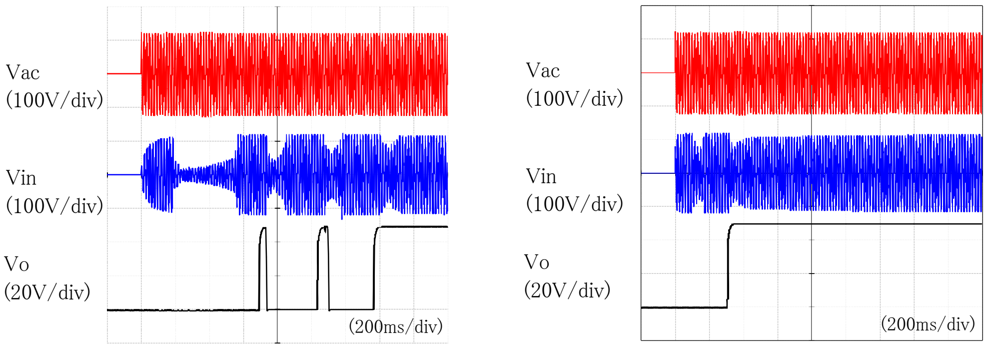
Load 0% to 100% (AC85Vin)

4.3 Relationship between unstable operation and input voltage

■When the input voltage is low, the area for unstable operation is extended.

■Fig. 4.3 shows differences in operation with input voltage.

Fig. 4.3
Difference in operation with Vin



Startup (AC85Vin)
<Unstable operation>

Startup (AC90Vin)
<Stable operation>

■Page A-14 shows boundary line examples between stable and unstable operation.
(Data were obtained from circuit connection shown in Fig. 2.1 with external parts shown in Table 2.1.)

5. Holdup Time

■ Holdup time is determined by the capacitance of Cbc. Fig. 5.1 and Fig. 5.2 shows the relationship between holdup time and load within the allowable capacitance of Cbc.

Fig. 5.1
Relationship between holdup time and Cbc (TUXS150)

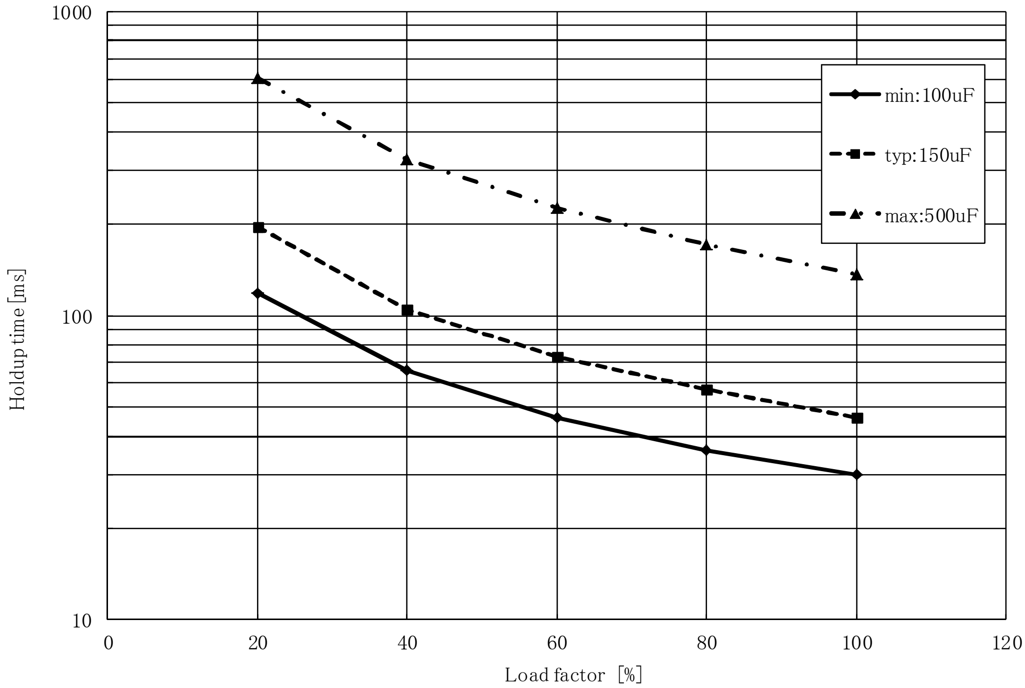
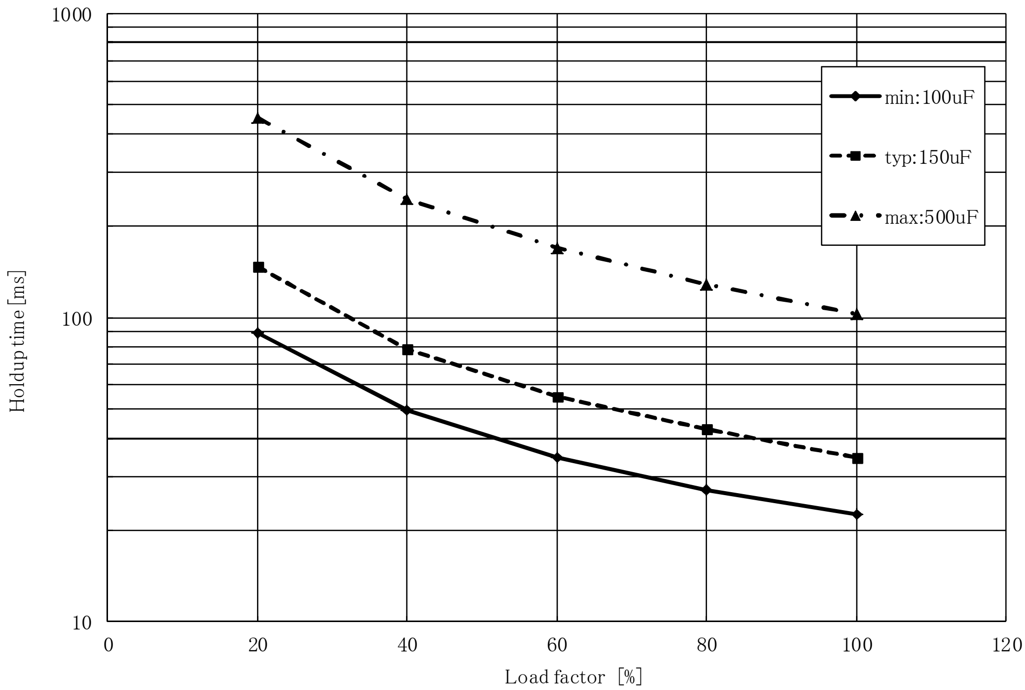


Fig. 5.2
Relationship between holdup time and Cbc (TUXS200)



6. Board layout

6.1 Consideration for board layout

- The potential voltage of each terminal is given below. External components that are connected to these terminals should be at same potential voltage.

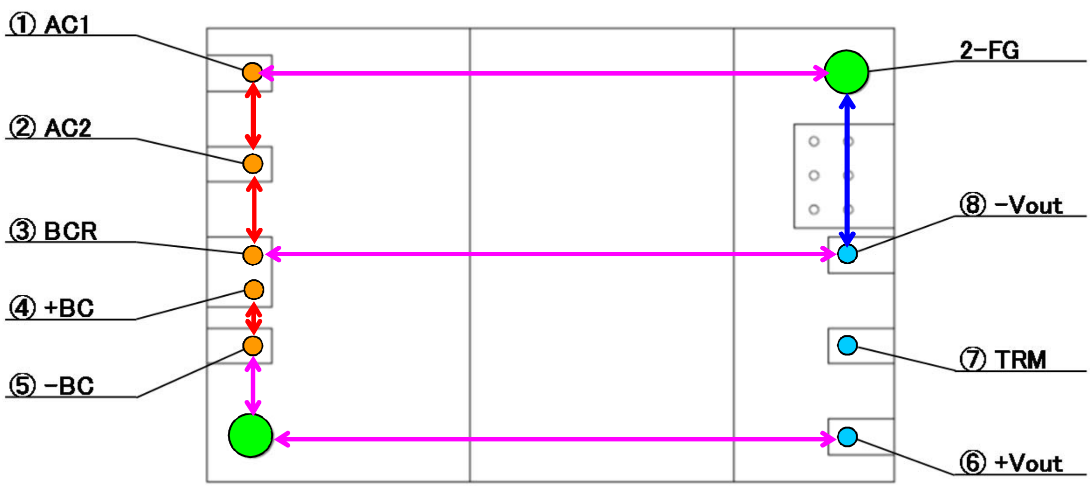
Primary (input side)	● (orange)	: AC, BC, BCR pin
Secondary (output side)	● (light blue)	: VOUT, TRM pin
FG (base plate)	● (green)	: Nut (2 places), Aluminum base plate, Heat sink

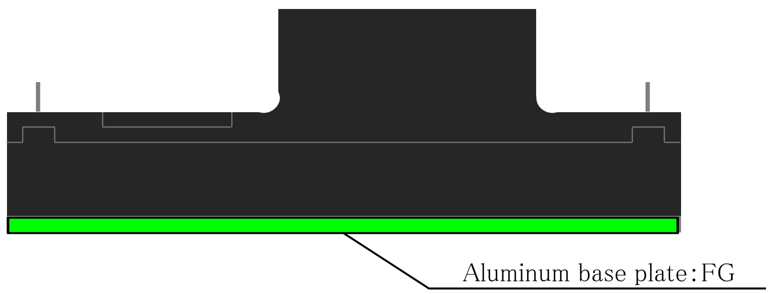
- In order to meet the breakdown voltage specification of products, insulation distance between components and between patterns is recommended to ensure the following.

Primary − Secondary	↔ (magenta)	: 5mm or more
Primary −FG	↔ (magenta)	: 5mm or more
Secondary − FG	↔ (blue)	: 1.6mm or more
Primary interphase	↔ (red)	: 3mm or more
Wiring of AC pin − BC pin	↔ (red)	: 3mm or more

- Clearance and creepage requirements vary based on different safety standards and conditions of usage. Please place the components and wiring pattern according to those safety standards.

Fig 6.1 Insulation distance





■ There are notes for printed circuit board design at recommended circuit in this applications manual. Please see below.

① Input fuse : F11

■ When the fuse is blown out, input voltage should be applied between the terminals of the fuse F11.
Please keep the distance of the pattern between the terminals of the fuse more than 2.5mm if you needto comply with safety approvals.

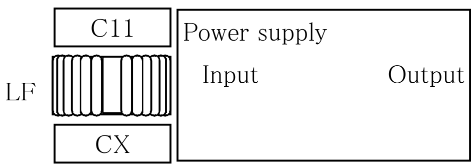
② Input capacitor : C11

■Huge ripple current flows into the X capacitor C11.
Place the X capacitor near the power supply as close as possible.

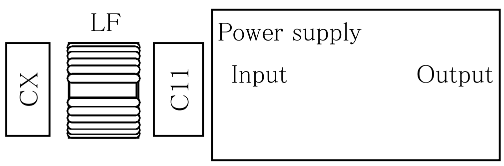
③ Noise filters

■ Noise filter is build by L11, L12, CX1, CX2 ,CY2 andCY3. And the Noise filter is used to reduce conduction noise from power supply.
Off-the-shelf Noise filter is also available.

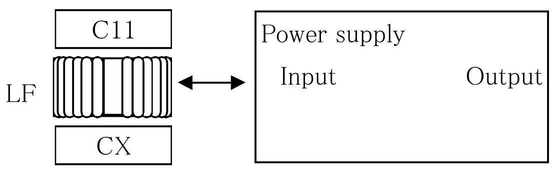
■ If the Line filter is placed near the components which are switching at high frequency, the conduction noise may be increased because the noise goes into the Line filter.
Therefore, the Line filter should be shielded or keep the distance from the source of noise



× Not good



○ Good



○ Good

■ The effect of noise reduction by Y capacitor depends on the place of the FG connection. Recommend connecting Y capacitor to the FG terminal of the power supply as close as possible. Please evaluate before use.

④ Inrush current limiting thermistor : TH11,TH21

■ Inrush current will flow through the Cbc and TH11 or TH21. Please have a pattern width that is not damaged by the inrush current.

⑤ Capacitor for boost voltage : Cbc,C20

■ Huge ripple current flows into the capacitor C20. Place C20 near the power supply as close as possible.

■ The high voltage(Approx. 380VDC) will be applied between +BC,BCR and −BC terminals. The distance between +BC, BCR and −BC terminals must be 3mm or more.

⑥ Output capacitors : Co, C40

■ Connecting the output capacitor (Co,C40) to the power module as close as possible for stable operation and radiation noise reduction.
Output line impedence could cause unstable output voltage, which can be reduced by adding the output capacitor close to the load.

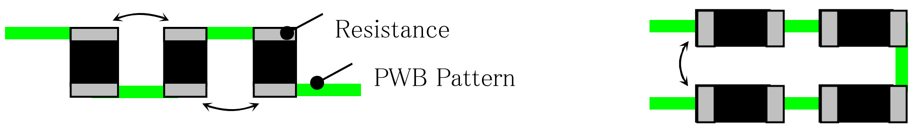
■ When the output ripple and ripple noise must be reduced, ceramic capacitor C40 which has good characteristics at high frequency should be used.
If through-hole type ceramic capacitor is used, the effect of the noise reduction would be reduced by the impedance of the lead frame of the components.
Please evaluate before using.

⑦ Surge Suppression : SK21,SK22,SK23, and SA11

■ In isolation test, test voltage is applied to the SA11. When the test voltage beyond the specification of the SA11 is applied, please remove the SA11 during the test, or lower the test voltage.
Note. When conducting isolation test between the primary and the secondary, high voltage is applied to SA11,SK21,SK22, and SK23, by the partial pressure of the Y capacitor.

⑧ Discharging resistor

■ Please keep distance between electrodes, when using multiple resistors for R1 due to loss variance.
In the case of apparatus for obtaining safety standards, please keep insulation distance required by the standard.



⑨ FG terminals of the power supply

■ Connect the FG terminal of the power supply to the PWB by screw. If the FG terminals of the power supply are not connected properly, malfunction or failure could happen.

■ Expose the solder mask around the hole of the FG connection on the PWB to connect FG terminals by screws.

6.2 Reference PCB layput

Fig. 6.4
Example of
the pattern
layput
(Top view)

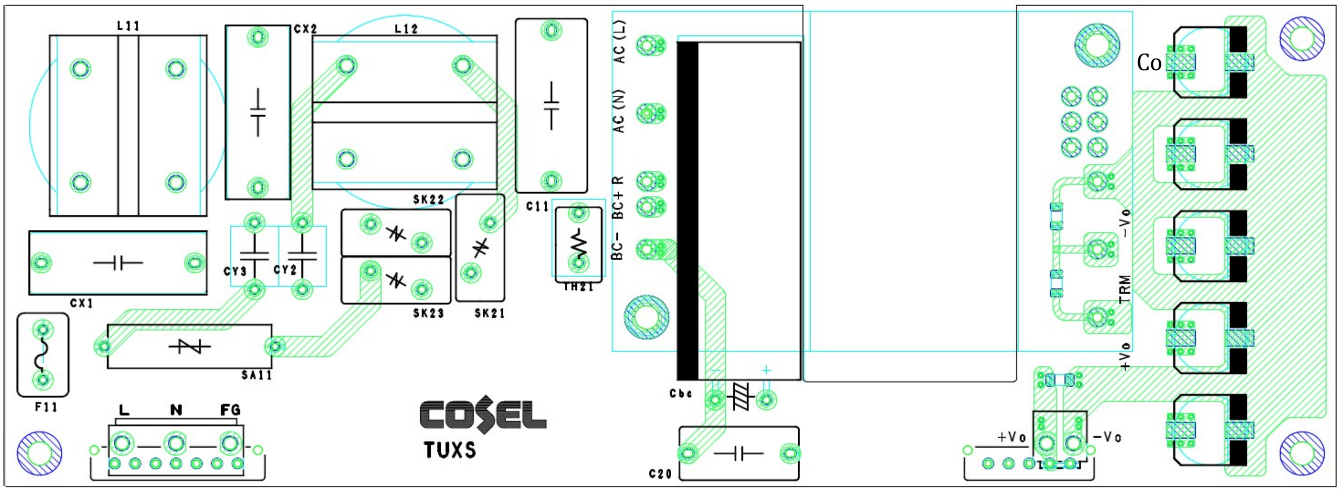
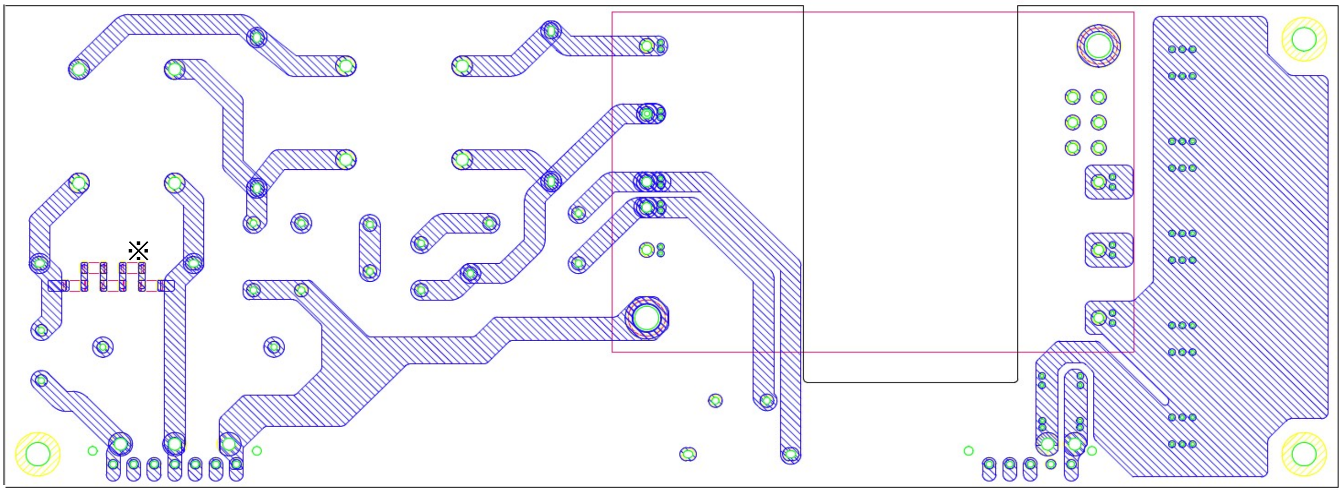


Fig6.4(a) Example of the pattern and components layout (Top layer)

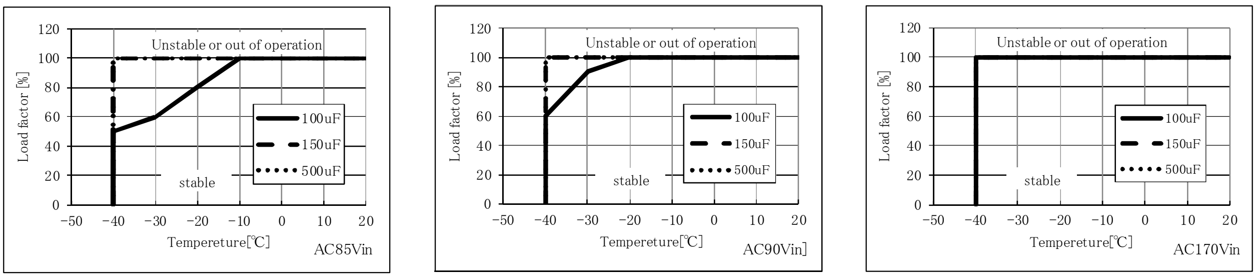


※Discharge resistance：Discharge resistance may be necessary depending on an acquired security standard.

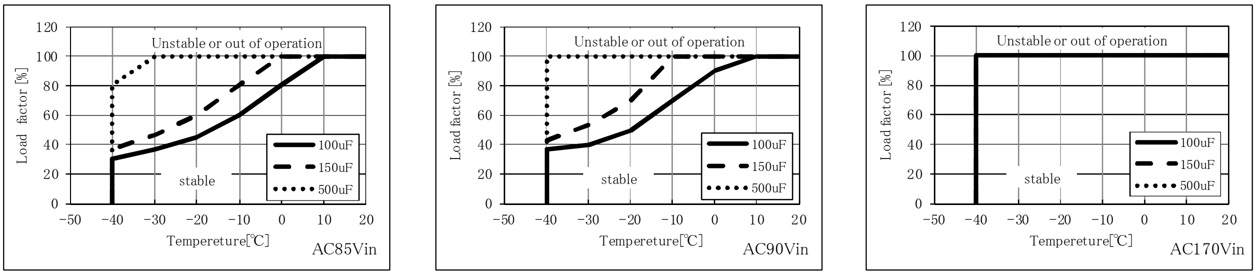
Fig6.4(b) Example of the pattern and components layput (Bottom layer)

Appendix

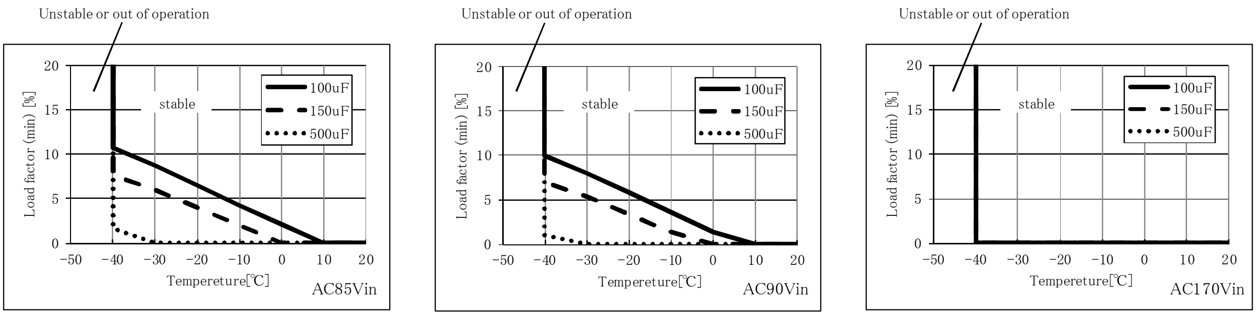
Fig. A
Boundary line
examples between
unstable and
stable operation
(TUXS150)



Boundary line of stable operation at startup

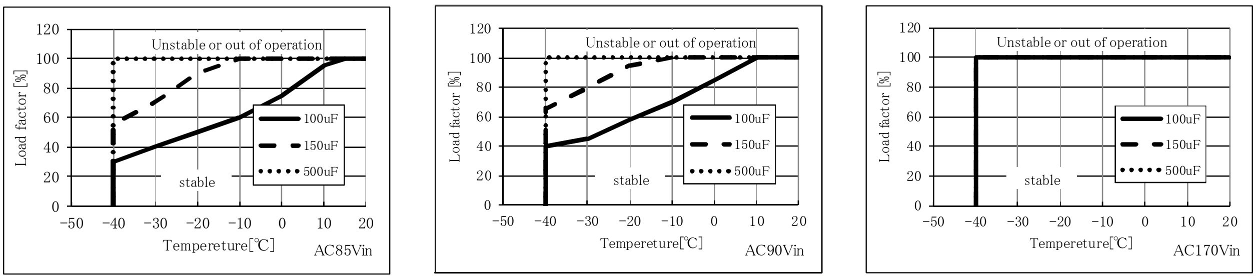


Boundary line of stable operation at dynamic load change from 0% to 100%

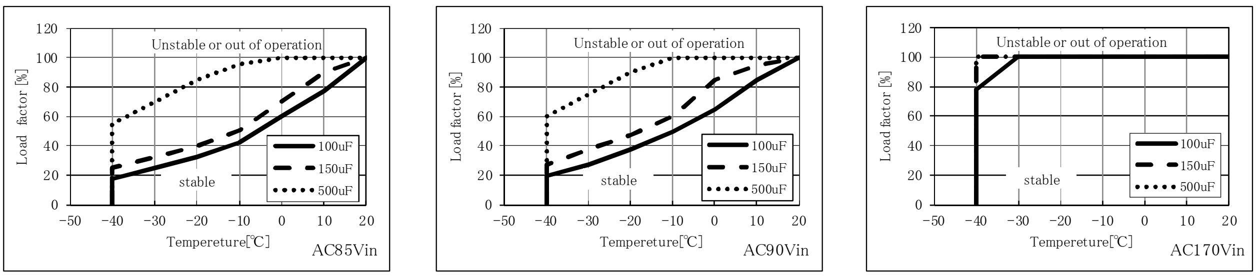


Boundary line of stable operation at dynamic load change from Load(min) to 100%

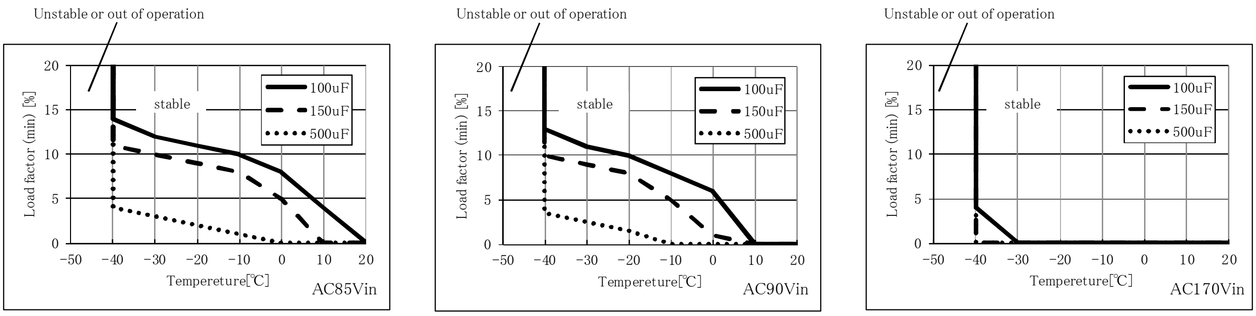
Fig. B
Boundary line
examples between
unstable and
stable operation
(TUXS200)



Boundary line of stable operation at startup



Boundary line of stable operation at dynamic load change from 0% to 100%



Boundary line of stable operation at dynamic load change from Load(min) to 100%